

Appendix A

Hardware Description in the Verilog language of a coder for coding data with the minimum pulse width of 2 sample periods and a maximum period between transitions of 22 sample periods.

```

5      //-----
      //
      //   file: coder_16B24B.v
      //
10     //   this is model of 16 to 24 bits encoder.
      //
      //
      //   revision history:
      //
15     //   14/08/2003 initial release. (ia)
      //-----

module CODER(
      D,                      // Data in
20     Q);                   // data output

input  [7:0] D;
output [11:0] Q;

25  reg    [11:0] Q;

always @(D) case (D)
      8'h00 : begin Q <= 12'b000000000000; end
      8'h01 : begin Q <= 12'b100000000000; end
30     8'h02 : begin Q <= 12'b110000000000; end
      8'h03 : begin Q <= 12'b011000000000; end
      8'h04 : begin Q <= 12'b111000000000; end
      8'h05 : begin Q <= 12'b001100000000; end
      8'h06 : begin Q <= 12'b011100000000; end
35     8'h07 : begin Q <= 12'b111100000000; end
      8'h08 : begin Q <= 12'b000110000000; end
      8'h09 : begin Q <= 12'b100110000000; end
      8'h0A : begin Q <= 12'b001110000000; end
      8'h0B : begin Q <= 12'b011110000000; end

```

```

      8'h0C : begin Q <= 12'b111110000000; end
      8'h0D : begin Q <= 12'b0000111000000; end
      8'h0E : begin Q <= 12'b1000111000000; end
      8'h0F : begin Q <= 12'b1100111000000; end
5      8'h10 : begin Q <= 12'b0001111000000; end
      8'h11 : begin Q <= 12'b1001111000000; end
      8'h12 : begin Q <= 12'b0011111000000; end
      8'h13 : begin Q <= 12'b0111111000000; end
      8'h14 : begin Q <= 12'b1111111000000; end
10     8'h15 : begin Q <= 12'b0000011100000; end
      8'h16 : begin Q <= 12'b1000011100000; end
      8'h17 : begin Q <= 12'b1100011100000; end
      8'h18 : begin Q <= 12'b0110011100000; end
      8'h19 : begin Q <= 12'b1110011100000; end
15     8'h1A : begin Q <= 12'b0000111100000; end
      8'h1B : begin Q <= 12'b1000111100000; end
      8'h1C : begin Q <= 12'b1100111100000; end
      8'h1D : begin Q <= 12'b0001111100000; end
      8'h1E : begin Q <= 12'b1001111100000; end
20     8'h1F : begin Q <= 12'b0011111100000; end
      8'h20 : begin Q <= 12'b0111111100000; end
      8'h21 : begin Q <= 12'b1111111100000; end
      8'h22 : begin Q <= 12'b0000001110000; end
      8'h23 : begin Q <= 12'b1000001110000; end
25     8'h24 : begin Q <= 12'b1100001110000; end
      8'h25 : begin Q <= 12'b0110001110000; end
      8'h26 : begin Q <= 12'b1110001110000; end
      8'h27 : begin Q <= 12'b0011001110000; end
      8'h28 : begin Q <= 12'b0111001110000; end
30     8'h29 : begin Q <= 12'b1111001110000; end
      8'h2A : begin Q <= 12'b0000011110000; end
      8'h2B : begin Q <= 12'b1000011110000; end
      8'h2C : begin Q <= 12'b1100011110000; end
      8'h2D : begin Q <= 12'b0110011110000; end
35     8'h2E : begin Q <= 12'b1110011110000; end
      8'h2F : begin Q <= 12'b0000111110000; end
      8'h30 : begin Q <= 12'b1000111110000; end
      8'h31 : begin Q <= 12'b1100111110000; end
      8'h32 : begin Q <= 12'b0001111110000; end

```

	8'h33	: begin Q <= 12'b100111110000; end
	8'h34	: begin Q <= 12'b001111110000; end
	8'h35	: begin Q <= 12'b011111110000; end
	8'h36	: begin Q <= 12'b111111110000; end
5	8'h37	: begin Q <= 12'b000000011000; end
	8'h38	: begin Q <= 12'b100000011000; end
	8'h39	: begin Q <= 12'b110000011000; end
	8'h3A	: begin Q <= 12'b011000011000; end
	8'h3B	: begin Q <= 12'b111000011000; end
10	8'h3C	: begin Q <= 12'b001100011000; end
	8'h3D	: begin Q <= 12'b011100011000; end
	8'h3E	: begin Q <= 12'b111100011000; end
	8'h3F	: begin Q <= 12'b000110011000; end
	8'h40	: begin Q <= 12'b100110011000; end
15	8'h41	: begin Q <= 12'b001110011000; end
	8'h42	: begin Q <= 12'b011110011000; end
	8'h43	: begin Q <= 12'b111110011000; end
	8'h44	: begin Q <= 12'b000000111000; end
	8'h45	: begin Q <= 12'b100000111000; end
20	8'h46	: begin Q <= 12'b110000111000; end
	8'h47	: begin Q <= 12'b011000111000; end
	8'h48	: begin Q <= 12'b111000111000; end
	8'h49	: begin Q <= 12'b001100111000; end
	8'h4A	: begin Q <= 12'b011100111000; end
25	8'h4B	: begin Q <= 12'b111100111000; end
	8'h4C	: begin Q <= 12'b000001111000; end
	8'h4D	: begin Q <= 12'b100001111000; end
	8'h4E	: begin Q <= 12'b110001111000; end
	8'h4F	: begin Q <= 12'b011001111000; end
30	8'h50	: begin Q <= 12'b111001111000; end
	8'h51	: begin Q <= 12'b000011111000; end
	8'h52	: begin Q <= 12'b100011111000; end
	8'h53	: begin Q <= 12'b110011111000; end
	8'h54	: begin Q <= 12'b000111111000; end
35	8'h55	: begin Q <= 12'b100111111000; end
	8'h56	: begin Q <= 12'b001111111000; end
	8'h57	: begin Q <= 12'b011111111000; end
	8'h58	: begin Q <= 12'b111111111000; end
	8'h59	: begin Q <= 12'b000000001100; end

	8'h5A	: begin Q <= 12'b100000001100; end
	8'h5B	: begin Q <= 12'b110000001100; end
	8'h5C	: begin Q <= 12'b011000001100; end
	8'h5D	: begin Q <= 12'b111000001100; end
5	8'h5E	: begin Q <= 12'b001100001100; end
	8'h5F	: begin Q <= 12'b011100001100; end
	8'h60	: begin Q <= 12'b111100001100; end
	8'h61	: begin Q <= 12'b000110001100; end
	8'h62	: begin Q <= 12'b100110001100; end
10	8'h63	: begin Q <= 12'b001110001100; end
	8'h64	: begin Q <= 12'b011110001100; end
	8'h65	: begin Q <= 12'b111110001100; end
	8'h66	: begin Q <= 12'b000011001100; end
	8'h67	: begin Q <= 12'b100011001100; end
15	8'h68	: begin Q <= 12'b110011001100; end
	8'h69	: begin Q <= 12'b000111001100; end
	8'h6A	: begin Q <= 12'b100111001100; end
	8'h6B	: begin Q <= 12'b001111001100; end
	8'h6C	: begin Q <= 12'b011111001100; end
20	8'h6D	: begin Q <= 12'b111111001100; end
	8'h6E	: begin Q <= 12'b000000011100; end
	8'h6F	: begin Q <= 12'b100000011100; end
	8'h70	: begin Q <= 12'b110000011100; end
	8'h71	: begin Q <= 12'b011000011100; end
25	8'h72	: begin Q <= 12'b111000011100; end
	8'h73	: begin Q <= 12'b001100011100; end
	8'h74	: begin Q <= 12'b011100011100; end
	8'h75	: begin Q <= 12'b111100011100; end
	8'h76	: begin Q <= 12'b000110011100; end
30	8'h77	: begin Q <= 12'b100110011100; end
	8'h78	: begin Q <= 12'b001110011100; end
	8'h79	: begin Q <= 12'b011110011100; end
	8'h7A	: begin Q <= 12'b111110011100; end
	8'h7B	: begin Q <= 12'b000000111100; end
35	8'h7C	: begin Q <= 12'b100000111100; end
	8'h7D	: begin Q <= 12'b110000111100; end
	8'h7E	: begin Q <= 12'b011000111100; end
	8'h7F	: begin Q <= 12'b111000111100; end
	8'h80	: begin Q <= 12'b001100111100; end

```

      8'h81 : begin Q <= 12'b0111001111100; end
      8'h82 : begin Q <= 12'b1111001111100; end
      8'h83 : begin Q <= 12'b0000011111100; end
      8'h84 : begin Q <= 12'b1000011111100; end
5      8'h85 : begin Q <= 12'b1100011111100; end
      8'h86 : begin Q <= 12'b0110011111100; end
      8'h87 : begin Q <= 12'b1110011111100; end
      8'h88 : begin Q <= 12'b0000111111100; end
      8'h89 : begin Q <= 12'b1000111111100; end
10     8'h8A : begin Q <= 12'b1100111111100; end
      8'h8B : begin Q <= 12'b0001111111100; end
      8'h8C : begin Q <= 12'b1001111111100; end
      8'h8D : begin Q <= 12'b0011111111100; end
      8'h8E : begin Q <= 12'b0111111111100; end
15     8'h8F : begin Q <= 12'b1111111111100; end
      8'h90 : begin Q <= 12'b000000000110; end
      8'h91 : begin Q <= 12'b100000000110; end
      8'h92 : begin Q <= 12'b110000000110; end
      8'h93 : begin Q <= 12'b011000000110; end
20     8'h94 : begin Q <= 12'b111000000110; end
      8'h95 : begin Q <= 12'b001100000110; end
      8'h96 : begin Q <= 12'b011100000110; end
      8'h97 : begin Q <= 12'b111100000110; end
      8'h98 : begin Q <= 12'b000110000110; end
25     8'h99 : begin Q <= 12'b100110000110; end
      8'h9A : begin Q <= 12'b001110000110; end
      8'h9B : begin Q <= 12'b011110000110; end
      8'h9C : begin Q <= 12'b111110000110; end
      8'h9D : begin Q <= 12'b000011000110; end
30     8'h9E : begin Q <= 12'b100011000110; end
      8'h9F : begin Q <= 12'b110011000110; end
      8'hA0 : begin Q <= 12'b000111000110; end
      8'hA1 : begin Q <= 12'b100111000110; end
      8'hA2 : begin Q <= 12'b001111000110; end
35     8'hA3 : begin Q <= 12'b011111000110; end
      8'hA4 : begin Q <= 12'b111111000110; end
      8'hA5 : begin Q <= 12'b000001100110; end
      8'hA6 : begin Q <= 12'b100001100110; end
      8'hA7 : begin Q <= 12'b110001100110; end

```

	8'hA8	: begin Q <= 12'b011001100110; end
	8'hA9	: begin Q <= 12'b111001100110; end
	8'hAA	: begin Q <= 12'b000011100110; end
	8'hAB	: begin Q <= 12'b100011100110; end
5	8'hAC	: begin Q <= 12'b110011100110; end
	8'hAD	: begin Q <= 12'b000111100110; end
	8'hAE	: begin Q <= 12'b100111100110; end
	8'hAF	: begin Q <= 12'b001111100110; end
	8'hB0	: begin Q <= 12'b011111100110; end
10	8'hB1	: begin Q <= 12'b111111100110; end
	8'hB2	: begin Q <= 12'b000000001110; end
	8'hB3	: begin Q <= 12'b100000001110; end
	8'hB4	: begin Q <= 12'b110000001110; end
	8'hB5	: begin Q <= 12'b011000001110; end
15	8'hB6	: begin Q <= 12'b111000001110; end
	8'hB7	: begin Q <= 12'b001100001110; end
	8'hB8	: begin Q <= 12'b011100001110; end
	8'hB9	: begin Q <= 12'b111100001110; end
	8'hBA	: begin Q <= 12'b000110001110; end
20	8'hBB	: begin Q <= 12'b100110001110; end
	8'hBC	: begin Q <= 12'b001110001110; end
	8'hBD	: begin Q <= 12'b011110001110; end
	8'hBE	: begin Q <= 12'b111110001110; end
	8'hBF	: begin Q <= 12'b000011001110; end
25	8'hC0	: begin Q <= 12'b100011001110; end
	8'hC1	: begin Q <= 12'b110011001110; end
	8'hC2	: begin Q <= 12'b000111001110; end
	8'hC3	: begin Q <= 12'b100111001110; end
	8'hC4	: begin Q <= 12'b001111001110; end
30	8'hC5	: begin Q <= 12'b011111001110; end
	8'hC6	: begin Q <= 12'b111111001110; end
	8'hC7	: begin Q <= 12'b000000011110; end
	8'hC8	: begin Q <= 12'b100000011110; end
	8'hC9	: begin Q <= 12'b110000011110; end
35	8'hCA	: begin Q <= 12'b011000011110; end
	8'hCB	: begin Q <= 12'b111000011110; end
	8'hCC	: begin Q <= 12'b001100011110; end
	8'hCD	: begin Q <= 12'b011100011110; end
	8'hCE	: begin Q <= 12'b111100011110; end

```

      8'hCF : begin Q <= 12'b0001100111110; end
      8'hD0 : begin Q <= 12'b1001100111110; end
      8'hD1 : begin Q <= 12'b0011100111110; end
      8'hD2 : begin Q <= 12'b0111100111110; end
5      8'hD3 : begin Q <= 12'b1111100111110; end
      8'hD4 : begin Q <= 12'b0000001111110; end
      8'hD5 : begin Q <= 12'b1000001111110; end
      8'hD6 : begin Q <= 12'b1100001111110; end
      8'hD7 : begin Q <= 12'b0110001111110; end
10     8'hD8 : begin Q <= 12'b1110001111110; end
      8'hD9 : begin Q <= 12'b0011001111110; end
      8'hDA : begin Q <= 12'b0111001111110; end
      8'hDB : begin Q <= 12'b1111001111110; end
      8'hDC : begin Q <= 12'b0000011111110; end
15     8'hDD : begin Q <= 12'b1000011111110; end
      8'hDE : begin Q <= 12'b1100011111110; end
      8'hDF : begin Q <= 12'b0110011111110; end
      8'hE0 : begin Q <= 12'b1110011111110; end
      8'hE1 : begin Q <= 12'b0000111111110; end
20     8'hE2 : begin Q <= 12'b1000111111110; end
      8'hE3 : begin Q <= 12'b1100111111110; end
      8'hE4 : begin Q <= 12'b0001111111110; end
      8'hE5 : begin Q <= 12'b1001111111110; end
      8'hE6 : begin Q <= 12'b0011111111110; end
25     8'hE7 : begin Q <= 12'b0111111111110; end
      8'hE8 : begin Q <= 12'b1111111111110; end
      default : begin Q <= 12'hxxx; end
    endcase

30  endmodule

    module CODER_16B24B(
        DA,                // Data in lane A
        DB,                // Data in lane B
35     P,                  // Polarity
        Q);                // data output

    input  [8:0] DA;        // {CMD,AH,AG,AF,AE,AD,AC,AB,AA} lane A
    input  [8:0] DB;        // {CMD,BH,BG,BF,BE,BD,BC,BB,BA} lane B

```

```

input          P;    //
output [23:0] Q;    // B{l,k,j,h,g,f,i,e,d,c,b,a} A{l,k,j,h,g,f,i,e,d,c,b,a}

reg            [23:0] Q;

5
    //-----
    // internal signals:
    //-----

10 wire          va;
   wire          vb;
   wire    [11:0] qa;
   wire    [11:0] qb;
   wire    [5:0]  ra;
15 wire    [5:0]  rb;
   reg     [7:0]  sa;
   reg     [7:0]  sb;
   reg     [23:0] qr;

20    //-----
    // code:
    //-----

   assign va = DA >= 232;
25   assign vb = DB >= 232;
   assign ra = DA - 232;
   assign rb = DB - 232;

   always @(DA or DB or va or vb) begin
30       if (va) begin
           sa <= {ra,DB[1:0]};
           sb <= {DB[8:2],1'b0};
       end
       else if (vb) begin
35           sa <= {rb,DA[1:0]};
           sb <= {DA[8:2],1'b1};
       end
       else begin
           sa <= DA[7:0] + 1;

```

```

        sb <= DB[7:0] + 1;
    end
end

5  CODER CA(.D(sa), .Q(qa));
   CODER CB(.D(sb), .Q(qb));

   always @(qa or qb or va or vb) qr <= {{12{(va || vb)^qa[0]}}^qb, qa[0],
   qa[1], qa[2], qa[3], qa[4], qa[5], qa[6], qa[7], qa[8], qa[9], qa[10], qa[11]}};
10  always @(P or qr) Q <= {24{P^qr[0]}}^qr;

endmodule

```

Appendix B

Hardware Description in the Verilog language of a decoder for coding data with the minimum pulse width of 2 sample periods and a maximum period between transitions of 22 sample periods.

```

5
//-----
//
//    file: decoder_16B24B.v
10 //
//    this is model of 24 to 16 bits decoder.
//
//
//    revision history:
15 //
//    14/08/2003 initial release. (ia)
//-----

module DECODER(
20     D,                // Data in
    Q);                // data output

input  [11:0] D;
output [7:0] Q;

25 reg      [7:0] Q;

always @(D) case (D)
    12'b000000000000 : begin Q <= 8'h00; end
30    12'b100000000000 : begin Q <= 8'h01; end
    12'b110000000000 : begin Q <= 8'h02; end
    12'b011000000000 : begin Q <= 8'h03; end
    12'b111000000000 : begin Q <= 8'h04; end
    12'b001100000000 : begin Q <= 8'h05; end
35    12'b011100000000 : begin Q <= 8'h06; end
    12'b111100000000 : begin Q <= 8'h07; end
    12'b000110000000 : begin Q <= 8'h08; end
    12'b100110000000 : begin Q <= 8'h09; end
    12'b001110000000 : begin Q <= 8'h0A; end

```

	12'b0111110000000	: begin Q <= 8'h0B; end
	12'b1111110000000	: begin Q <= 8'h0C; end
	12'b0000110000000	: begin Q <= 8'h0D; end
	12'b1000110000000	: begin Q <= 8'h0E; end
5	12'b1100110000000	: begin Q <= 8'h0F; end
	12'b0001110000000	: begin Q <= 8'h10; end
	12'b1001110000000	: begin Q <= 8'h11; end
	12'b0011110000000	: begin Q <= 8'h12; end
	12'b0111110000000	: begin Q <= 8'h13; end
10	12'b1111110000000	: begin Q <= 8'h14; end
	12'b0000011000000	: begin Q <= 8'h15; end
	12'b1000011000000	: begin Q <= 8'h16; end
	12'b1100011000000	: begin Q <= 8'h17; end
	12'b0110011000000	: begin Q <= 8'h18; end
15	12'b1110011000000	: begin Q <= 8'h19; end
	12'b0000111000000	: begin Q <= 8'h1A; end
	12'b1000111000000	: begin Q <= 8'h1B; end
	12'b1100111000000	: begin Q <= 8'h1C; end
	12'b0001111000000	: begin Q <= 8'h1D; end
20	12'b1001111000000	: begin Q <= 8'h1E; end
	12'b0011111000000	: begin Q <= 8'h1F; end
	12'b0111111000000	: begin Q <= 8'h20; end
	12'b1111111000000	: begin Q <= 8'h21; end
	12'b0000001100000	: begin Q <= 8'h22; end
25	12'b1000001100000	: begin Q <= 8'h23; end
	12'b1100001100000	: begin Q <= 8'h24; end
	12'b0110001100000	: begin Q <= 8'h25; end
	12'b1110001100000	: begin Q <= 8'h26; end
	12'b0011001100000	: begin Q <= 8'h27; end
30	12'b0111001100000	: begin Q <= 8'h28; end
	12'b1111001100000	: begin Q <= 8'h29; end
	12'b0000011100000	: begin Q <= 8'h2A; end
	12'b1000011100000	: begin Q <= 8'h2B; end
	12'b1100011100000	: begin Q <= 8'h2C; end
35	12'b0110011100000	: begin Q <= 8'h2D; end
	12'b1110011100000	: begin Q <= 8'h2E; end
	12'b0000111100000	: begin Q <= 8'h2F; end
	12'b1000111100000	: begin Q <= 8'h30; end
	12'b1100111100000	: begin Q <= 8'h31; end

	12'b0001111110000	: begin Q <= 8'h32; end
	12'b1001111110000	: begin Q <= 8'h33; end
	12'b0011111110000	: begin Q <= 8'h34; end
	12'b0111111110000	: begin Q <= 8'h35; end
5	12'b1111111110000	: begin Q <= 8'h36; end
	12'b000000011000	: begin Q <= 8'h37; end
	12'b100000011000	: begin Q <= 8'h38; end
	12'b110000011000	: begin Q <= 8'h39; end
	12'b011000011000	: begin Q <= 8'h3A; end
10	12'b111000011000	: begin Q <= 8'h3B; end
	12'b001100011000	: begin Q <= 8'h3C; end
	12'b011100011000	: begin Q <= 8'h3D; end
	12'b111100011000	: begin Q <= 8'h3E; end
	12'b000110011000	: begin Q <= 8'h3F; end
15	12'b100110011000	: begin Q <= 8'h40; end
	12'b001110011000	: begin Q <= 8'h41; end
	12'b011110011000	: begin Q <= 8'h42; end
	12'b111110011000	: begin Q <= 8'h43; end
	12'b000000111000	: begin Q <= 8'h44; end
20	12'b100000111000	: begin Q <= 8'h45; end
	12'b110000111000	: begin Q <= 8'h46; end
	12'b011000111000	: begin Q <= 8'h47; end
	12'b111000111000	: begin Q <= 8'h48; end
	12'b001100111000	: begin Q <= 8'h49; end
25	12'b011100111000	: begin Q <= 8'h4A; end
	12'b111100111000	: begin Q <= 8'h4B; end
	12'b000001111000	: begin Q <= 8'h4C; end
	12'b100001111000	: begin Q <= 8'h4D; end
	12'b110001111000	: begin Q <= 8'h4E; end
30	12'b011001111000	: begin Q <= 8'h4F; end
	12'b111001111000	: begin Q <= 8'h50; end
	12'b000011111000	: begin Q <= 8'h51; end
	12'b100011111000	: begin Q <= 8'h52; end
	12'b110011111000	: begin Q <= 8'h53; end
35	12'b000111111000	: begin Q <= 8'h54; end
	12'b100111111000	: begin Q <= 8'h55; end
	12'b001111111000	: begin Q <= 8'h56; end
	12'b011111111000	: begin Q <= 8'h57; end
	12'b111111111000	: begin Q <= 8'h58; end

	12'b000000001100	: begin Q <= 8'h59; end
	12'b100000001100	: begin Q <= 8'h5A; end
	12'b110000001100	: begin Q <= 8'h5B; end
	12'b011000001100	: begin Q <= 8'h5C; end
5	12'b111000001100	: begin Q <= 8'h5D; end
	12'b001100001100	: begin Q <= 8'h5E; end
	12'b011100001100	: begin Q <= 8'h5F; end
	12'b111100001100	: begin Q <= 8'h60; end
	12'b000110001100	: begin Q <= 8'h61; end
10	12'b100110001100	: begin Q <= 8'h62; end
	12'b001110001100	: begin Q <= 8'h63; end
	12'b011110001100	: begin Q <= 8'h64; end
	12'b111110001100	: begin Q <= 8'h65; end
	12'b000011001100	: begin Q <= 8'h66; end
15	12'b100011001100	: begin Q <= 8'h67; end
	12'b110011001100	: begin Q <= 8'h68; end
	12'b000111001100	: begin Q <= 8'h69; end
	12'b100111001100	: begin Q <= 8'h6A; end
	12'b001111001100	: begin Q <= 8'h6B; end
20	12'b011111001100	: begin Q <= 8'h6C; end
	12'b111111001100	: begin Q <= 8'h6D; end
	12'b000000011100	: begin Q <= 8'h6E; end
	12'b100000011100	: begin Q <= 8'h6F; end
	12'b110000011100	: begin Q <= 8'h70; end
25	12'b011000011100	: begin Q <= 8'h71; end
	12'b111000011100	: begin Q <= 8'h72; end
	12'b001100011100	: begin Q <= 8'h73; end
	12'b011100011100	: begin Q <= 8'h74; end
	12'b111100011100	: begin Q <= 8'h75; end
30	12'b000110011100	: begin Q <= 8'h76; end
	12'b100110011100	: begin Q <= 8'h77; end
	12'b001110011100	: begin Q <= 8'h78; end
	12'b011110011100	: begin Q <= 8'h79; end
	12'b111110011100	: begin Q <= 8'h7A; end
35	12'b000000111100	: begin Q <= 8'h7B; end
	12'b100000111100	: begin Q <= 8'h7C; end
	12'b110000111100	: begin Q <= 8'h7D; end
	12'b011000111100	: begin Q <= 8'h7E; end
	12'b111000111100	: begin Q <= 8'h7F; end

	12'b001100111100	: begin Q <= 8'h80; end
	12'b011100111100	: begin Q <= 8'h81; end
	12'b111100111100	: begin Q <= 8'h82; end
	12'b000001111100	: begin Q <= 8'h83; end
5	12'b100001111100	: begin Q <= 8'h84; end
	12'b110001111100	: begin Q <= 8'h85; end
	12'b011001111100	: begin Q <= 8'h86; end
	12'b111001111100	: begin Q <= 8'h87; end
	12'b000011111100	: begin Q <= 8'h88; end
10	12'b100011111100	: begin Q <= 8'h89; end
	12'b110011111100	: begin Q <= 8'h8A; end
	12'b000111111100	: begin Q <= 8'h8B; end
	12'b100111111100	: begin Q <= 8'h8C; end
	12'b001111111100	: begin Q <= 8'h8D; end
15	12'b011111111100	: begin Q <= 8'h8E; end
	12'b111111111100	: begin Q <= 8'h8F; end
	12'b000000000110	: begin Q <= 8'h90; end
	12'b100000000110	: begin Q <= 8'h91; end
	12'b110000000110	: begin Q <= 8'h92; end
20	12'b011000000110	: begin Q <= 8'h93; end
	12'b111000000110	: begin Q <= 8'h94; end
	12'b001100000110	: begin Q <= 8'h95; end
	12'b011100000110	: begin Q <= 8'h96; end
	12'b111100000110	: begin Q <= 8'h97; end
25	12'b000110000110	: begin Q <= 8'h98; end
	12'b100110000110	: begin Q <= 8'h99; end
	12'b001110000110	: begin Q <= 8'h9A; end
	12'b011110000110	: begin Q <= 8'h9B; end
	12'b111110000110	: begin Q <= 8'h9C; end
30	12'b000011000110	: begin Q <= 8'h9D; end
	12'b100011000110	: begin Q <= 8'h9E; end
	12'b110011000110	: begin Q <= 8'h9F; end
	12'b000111000110	: begin Q <= 8'hA0; end
	12'b100111000110	: begin Q <= 8'hA1; end
35	12'b001111000110	: begin Q <= 8'hA2; end
	12'b011111000110	: begin Q <= 8'hA3; end
	12'b111111000110	: begin Q <= 8'hA4; end
	12'b000001100110	: begin Q <= 8'hA5; end
	12'b100001100110	: begin Q <= 8'hA6; end

	12'b110001100110	: begin Q <= 8'hA7; end
	12'b011001100110	: begin Q <= 8'hA8; end
	12'b111001100110	: begin Q <= 8'hA9; end
	12'b000011100110	: begin Q <= 8'hAA; end
5	12'b100011100110	: begin Q <= 8'hAB; end
	12'b110011100110	: begin Q <= 8'hAC; end
	12'b000111100110	: begin Q <= 8'hAD; end
	12'b100111100110	: begin Q <= 8'hAE; end
	12'b001111100110	: begin Q <= 8'hAF; end
10	12'b011111100110	: begin Q <= 8'hB0; end
	12'b111111100110	: begin Q <= 8'hB1; end
	12'b000000001110	: begin Q <= 8'hB2; end
	12'b100000001110	: begin Q <= 8'hB3; end
	12'b110000001110	: begin Q <= 8'hB4; end
15	12'b011000001110	: begin Q <= 8'hB5; end
	12'b111000001110	: begin Q <= 8'hB6; end
	12'b001100001110	: begin Q <= 8'hB7; end
	12'b011100001110	: begin Q <= 8'hB8; end
	12'b111100001110	: begin Q <= 8'hB9; end
20	12'b000110001110	: begin Q <= 8'hBA; end
	12'b100110001110	: begin Q <= 8'hBB; end
	12'b001110001110	: begin Q <= 8'hBC; end
	12'b011110001110	: begin Q <= 8'hBD; end
	12'b111110001110	: begin Q <= 8'hBE; end
25	12'b000011001110	: begin Q <= 8'hBF; end
	12'b100011001110	: begin Q <= 8'hC0; end
	12'b110011001110	: begin Q <= 8'hC1; end
	12'b000111001110	: begin Q <= 8'hC2; end
	12'b100111001110	: begin Q <= 8'hC3; end
30	12'b001111001110	: begin Q <= 8'hC4; end
	12'b011111001110	: begin Q <= 8'hC5; end
	12'b111111001110	: begin Q <= 8'hC6; end
	12'b000000011110	: begin Q <= 8'hC7; end
	12'b100000011110	: begin Q <= 8'hC8; end
35	12'b110000011110	: begin Q <= 8'hC9; end
	12'b011000011110	: begin Q <= 8'hCA; end
	12'b111000011110	: begin Q <= 8'hCB; end
	12'b001100011110	: begin Q <= 8'hCC; end
	12'b011100011110	: begin Q <= 8'hCD; end

```

12'b1111100011110 : begin Q <= 8'hCE; end
12'b0001110011110 : begin Q <= 8'hCF; end
12'b1001110011110 : begin Q <= 8'hD0; end
12'b0011110011110 : begin Q <= 8'hD1; end
5 12'b0111110011110 : begin Q <= 8'hD2; end
12'b1111110011110 : begin Q <= 8'hD3; end
12'b000000111110 : begin Q <= 8'hD4; end
12'b100000111110 : begin Q <= 8'hD5; end
12'b110000111110 : begin Q <= 8'hD6; end
10 12'b011000111110 : begin Q <= 8'hD7; end
12'b111000111110 : begin Q <= 8'hD8; end
12'b0011100111110 : begin Q <= 8'hD9; end
12'b0111100111110 : begin Q <= 8'hDA; end
12'b1111100111110 : begin Q <= 8'hDB; end
15 12'b000001111110 : begin Q <= 8'hDC; end
12'b100001111110 : begin Q <= 8'hDD; end
12'b110001111110 : begin Q <= 8'hDE; end
12'b011001111110 : begin Q <= 8'hDF; end
12'b111001111110 : begin Q <= 8'hE0; end
20 12'b000011111110 : begin Q <= 8'hE1; end
12'b100011111110 : begin Q <= 8'hE2; end
12'b110011111110 : begin Q <= 8'hE3; end
12'b000111111110 : begin Q <= 8'hE4; end
12'b100111111110 : begin Q <= 8'hE5; end
25 12'b001111111110 : begin Q <= 8'hE6; end
12'b011111111110 : begin Q <= 8'hE7; end
12'b111111111110 : begin Q <= 8'hE8; end
default : begin Q <= 8'hxx; end
endcase
30
endmodule

module DECODER_16B24B(
35      D,                // Data in
      QA,                // data output lane A
      QB);              // data output lane B

input  [23:0] D;         // B{1,k,j,h,g,f,i,e,d,c,b,a} A{1,k,j,h,g,f,i,e,d,c,b,a}
output [8:0] QA;         // {CMD,AH,AG,AF,AE,AD,AC,AB,AA} lane A

```

```

output    [8:0] QB;          // {CMD,AH,AG,AF,AE,AD,AC,AB,AA} lane B

reg        [8:0] QA;
reg        [8:0] QB;

5
    //-----
    // internal signals:
    //-----

10 wire    [8:0] s;
    wire    [11:0] sa;
    wire    [11:0] sb;
    wire    [7:0] qwa;
    wire    [7:0] qwb;
15 wire    [7:0] qwa_1;
    wire    [7:0] qwb_1;

    //-----
    // code:
20 //-----

    assign s  = qwa[7:2] + 232;
    assign sa = {12{D[11]}}^D[0],D[1],D[2],D[3],D[4],D[5],D[6],D[7],D[8],D[9],
    D[10],D[11]};
25 assign sb = {12{D[12]}}^D[23:12];
    assign qwa_1 = qwa - 1;
    assign qwb_1 = qwb - 1;

    DECODER DCA(.D(sa), .Q(qwa));
30 DECODER DCB(.D(sb), .Q(qwb));

    always @(D or qwa or qwb) begin
        if (D[12]^D[11]) begin
            if (qwb[0]) begin
35                 QA <= {qwb[7:1],qwa[1:0]};
                 QB <= s;
            end
            else begin
40                 QB <= {qwb[7:1],qwa[1:0]};
                 QA <= s;
            end
        end
    end

```

```
        end
    end
    else begin
        QA <= {1'b0,qwa_1};
        QB <= {1'b0,qwb_1};
    end
end
endmodule
```

5

10